



**Arizona  
Department of Transportation**

**Participant Manual**

for

**EXCAVATION  
& EMBANKMENT  
INSPECTION  
(Course Number 102)**

a training course developed  
for the

**ARIZONA DEPARTMENT OF TRANSPORTATION**  
Phoenix, Arizona

by

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# Directions To Manual Users

**Excavation and Embankment Inspection** (Course Number 102) is one in a series of training courses on inspection and quality control for earthwork and incidentals construction. Other courses in the series include:

- Pipe Placement Inspection (Course 103);
- Subgrade and Base Course Inspection (Course 104); and
- Incidentals Inspection (Course 105).

This course is designed primarily for highway construction inspection personnel, but it can also be used in training other personnel.

This manual is to be used in conjunction with discussion sessions with the trainee's instructor or supervisor, and other materials that make up the course. As sections of this manual are assigned, each trainee should:

1. read and study the material to review previously presented information and gain additional details,
2. complete the exercises and quizzes as they are provided,
3. check his answers against those provided following the exercise or quiz,
4. review the material as needed to correct and clarify any incorrect answers, and
5. discuss any areas that are still not clearly understood with his instructor or supervisor.

Each trainee should be provided with his own copy of this manual so that he can write in it and keep it for future reference and review.

This course is based primarily on the following sections in *ADOT Standard Specifications for Road and Bridge Construction*:

- 201 – Clearing and Grubbing,
- 202 – Removal of Structures and Obstructions,
- 203 – Earthwork,
- 209 – Furnish Water and
- 925 – Construction Surveying & Layout.

The following indirect references also were made:

- 105.08 – Cooperation with Utility Companies,
- 107.11 – Protection and Restoration of Property and Landscape, and
- 107.12 – Contractor's Responsibilities for Utility Property and Service.

The following sections of the Arizona Department of Transportation's 1998 Construction Manual also provided information for this course:

- 201 – Clearing and Grubbing,
- 202 – Removal of Structures and Obstructions,
- 203 – Earthwork,
- 1109 – Slope Stakes (Chapter 11-Surveying), and
- 1110 – Drainage Stakes (Chapter 11-Surveying).

# Section One: Pre-Construction Preparations

## Utility Removal and Relocation

When utility fixtures, pipelines, and other appurtenances are within or adjacent to a road construction area, the Department of Transportation will notify the utility companies to undertake necessary removal and replacement operations. The utility companies which own the affected pipe lines, valve boxes, light standards, cables, signals, and other appurtenances are responsible for making the necessary adjustments or removals. The contractor must make every effort to cooperate with the utility companies. If the utility companies fail to adjust or relocate their facilities as provided for in the contract, compensation and an extension in contract time may be granted to offset the contractor's losses which are beyond his control. The project plans will often identify specific lines to be installed by contractor forces for different utility companies or municipalities.

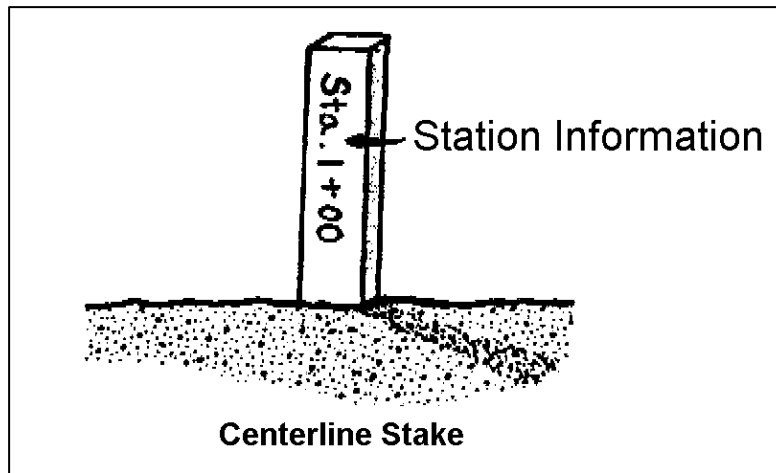
## Layout and Grade Controls

Layout and changes in grade for new construction are referenced by the placement of various stakes that contain pertinent information. Although the actual placement of these stakes is the responsibility of the contractor's survey crew, you must be able to understand their placement and the posted information. All stakes must be set so you can see them from the roadway. Refer to Section 925 of the *Standard Specifications*.

In addition, all breaks in topography are not staked but information regarding their location is contained in the slope stake book provided to the contractor in Subsection 925-2. Let's take a look at each of the stakes and their individual purposes. However, when a contractor's survey is required, the contractor is required to submit, and have approved, a survey plan which follows accepted practices in the *Construction Manual*, Chapter 11. It is crucial that the inspector have input in the survey review because understanding of how the project is staked will be a key item for documentation and payment.

**Centerline** stakes are the first to be placed. These stakes mark the centerline of the road to be constructed. They are usually placed every hundred feet. The locations where they are placed are referred to as *stations*. The centerline stakes contain important information, as do other stakes.

The station number on the centerline stake reflects the distance of the stake in feet from the beginning of this roadway project. If the centerline stake is 100 feet from the beginning of the roadway project, the beginning station is zero (0+00) and it would look like the illustration on page 4 .



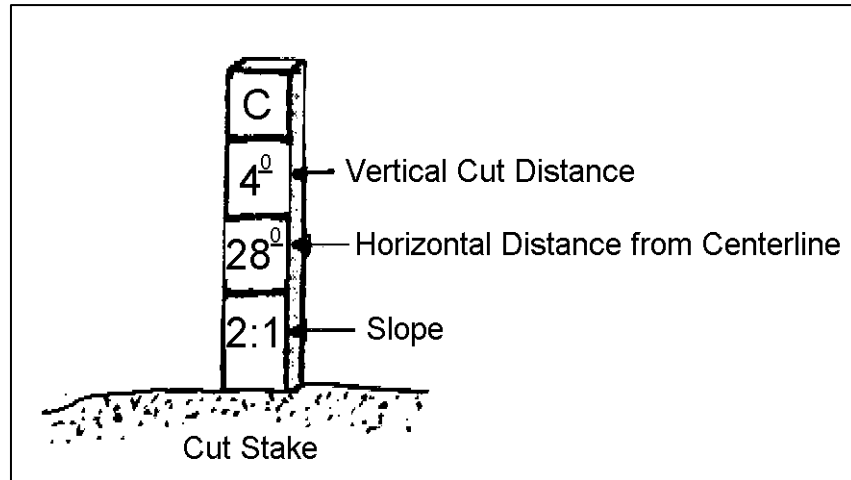
If the centerline stake was placed 15 feet beyond the station at 100 feet because of topographical obstructions, it would look like this:

**Right-of-way-stakes** are usually the next to be placed. They are set at the limits of the staked property. No work shall take place beyond these stakes unless a Temporary Construction Easement (TCE) has been acquired to work on private property. The only information contained on these stakes would be “R/W” (for right-of-way) or “FL” (for fence line) or similar markings representing various rights-of-way. Keep in mind, the fence line is not always the right-of-way because there is an offset distance between the two.

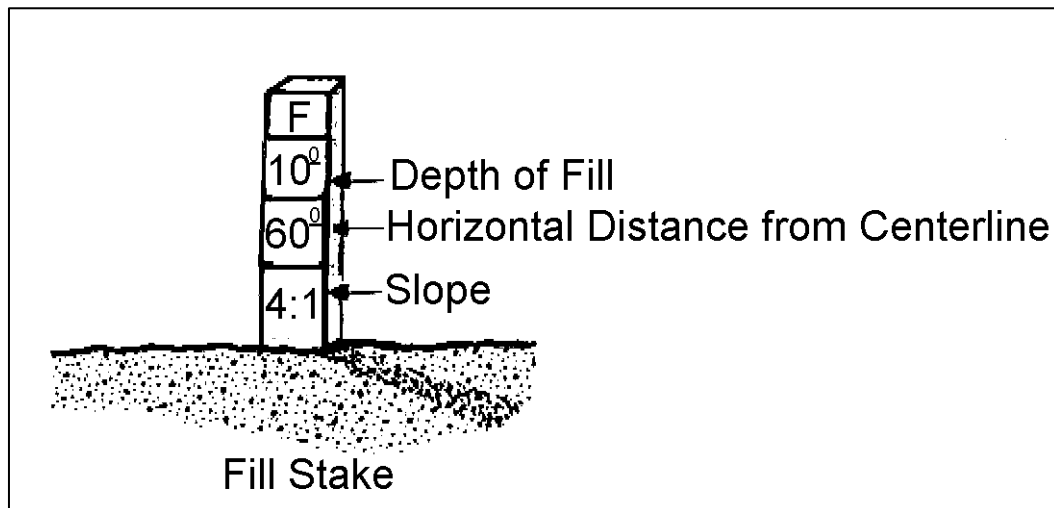
**Slope stakes** outline the cut and fill limits for the contractor. Cross-sectioning is usually done at the same time slope stakes are set. These stakes are to be set at 50-foot stations within the construction area which affect volume calculations for excavations and embankments. However with the use of Pre-determined Earthwork Quantities it is normally acceptable to run checks rather than calculate the entire roadway quantity.

On slope stakes, the station information is posted just like it is on the centerline stakes, regardless whether these slope stakes are for cut or fill.

The cut or fill information is posted on the opposite side of the stake. For example, let us look at a slope stake for making a cut. The vertical cut will be 4.0 feet down. Using the established centerline as a reference, the horizontal distance from the centerline is 28.0 feet. The desired slope is 2:1. The front of the cut stake should look like this:

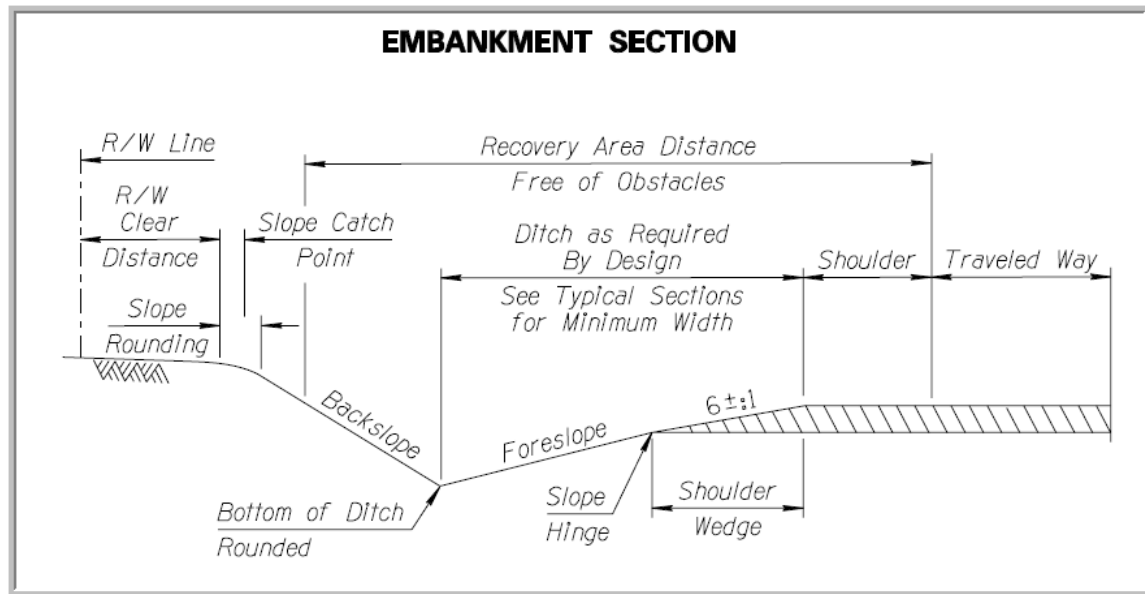


The fill stake contains information similar to that found on a cut stake. Suppose we need to add 10.0 feet of fill, the stake is to be positioned 60.0 feet from the centerline, and the desired slope is 4:1. This fill stake would look like this:

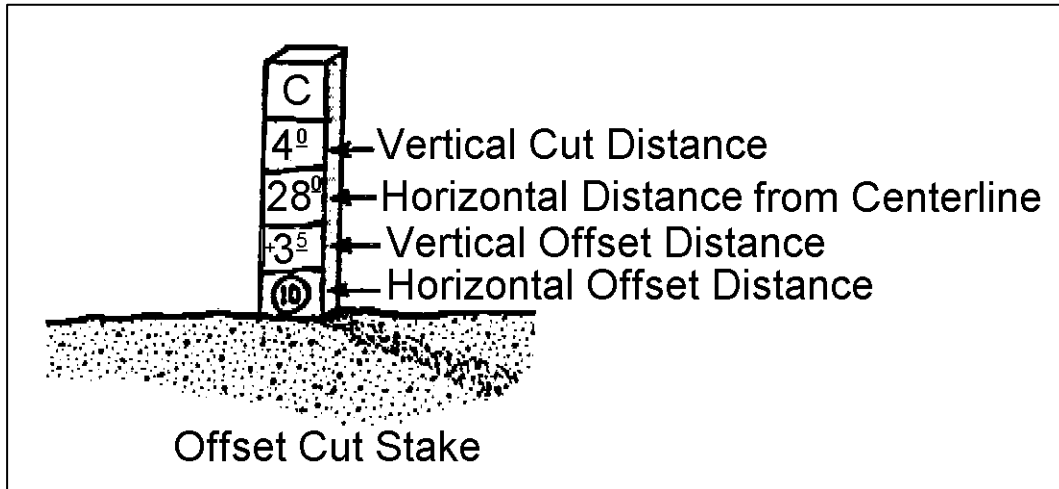




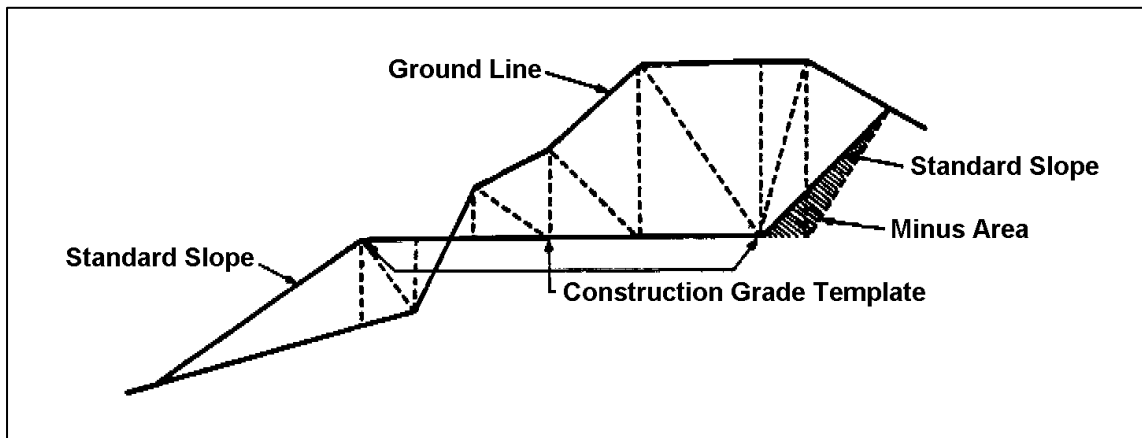
Slope measurements are a ratio of the horizontal(H) distance to the vertical(V) distance. So if a slope was 18 feet long and 6 feet high this would be a 3 to 1 slope, also designated 3:1; 3H:1V. In ADOT slopes are designated as either foreslope or backslope. The following figure illustrates that a foreslope is the distance from the top of the slope (roadway) to the intersection with level ground. The figure also illustrates that a backslope in combination with a foreslope forms a ditch.



Occasionally, cut stakes must be offset from their location because of the topography. In these instances, the station information is posted just like before; however, the cut information on the front is different. For example, if the vertical cut is still to 4.0 feet, the horizontal distance from the centerline is 28.0 feet; but, the vertical offset is 3.5 feet and the horizontal offset is usually 10 feet, the offset cut stake should look like this:<sup>1</sup>



**Roadway cross sections** may be taken because they serve as the quantity pay document for verifying work performed by the contractor. These sections are documented in a field book. As mentioned earlier, cross-sectioning and slope staking are usually performed at the same time. Stakes are placed at fifty-foot intervals but all grade breaks must be cross-sectioned.



<sup>1</sup> Although the above diagrams indicate the universally correct method of posting offsets, ADOT will often list the horizontal offset first and encircled.

**Drainage stakes** must be placed for crown dikes, crown ditches, dikes, ditches, and drainage channels. Care must be taken by the surveying crews to establish proper gradient and alignment to keep erosion to an absolute minimum. The placement of the stakes must conform to the dimensions and slopes as shown in plans. Use the same staking method that is used for the roadway.

## **Traffic Controls**

Traffic control must be planned by the contractor and approved in advance. All road construction must be undertaken in a manner which provides the least obstruction to traffic. Most importantly, the safety of the driving public, pedestrians, nearby residents, and construction personnel must be maintained during all road construction activity. Private property adjacent to the construction area also must be protected. The proper placement of all warning signs, barriers, barricades, lights and other protective devices must provide adequate warning to drivers and conform to state placement requirements. These devices must be maintained throughout the project.

## **Pre-Construction Conference**

The contractor must participate in a pre-construction conference with the Engineer to establish:

- progress schedules for completion of work,
- dates for equipment and materials procurement,
- authorized signature forms,
- list of proposed subcontractors and materials suppliers,
- EEO policy and compliance with other government regulations,
- traffic control and safety plan,
- erosion control and pollution prevention program where necessary,
- survey plan and survey payment schedule,
- quality control plan,
- partnering, and
- any other topics that need to be clarified.

## Section One Quiz

1. When setting up layout and grade controls, which stake is placed first? (Circle one)
  - a. slope stakes
  - b. right-of-way stakes
  - c. drainage stakes
  - d. centerline stakes
2. What information is contained on the back of all stakes? (Circle one)
  - a. station location
  - b. slope
  - c. vertical cut
  - d. horizontal offset
3. A station is ... (Circle one or more)
  - a. usually set up every 100 feet.
  - b. always expressed in feet and inches.
  - c. the measured distance from the beginning of the roadway project which is used as a reference point for placing all stakes.
  - d. established at all breaks in the topography.
4. Which of the following information may be found on a right-of-way stake? (Circle one or more)
  - a. horizontal offset
  - b. right-of-way
  - c. fence line
  - d. slope
5. Which information is **always** posted on a slope stake? (Circle one or more)
  - a. offset distances
  - b. horizontal distance from centerline
  - c. slope
  - d. vertical fill/cut distance
6. On an offset stake, how is the offset universally posted? (Circle one)
  - a. vertical offset, horizontal offset encircled
  - b. horizontal offset, vertical

7. Roadway cross-sections are important because they ... (Circle one)
  - a. determine where the stakes are placed.
  - b. mark utility locations.
  - c. serve as a pay document for the contractor.
  
8. Most importantly, traffic control must ... (Circle one)
  - a. allow sufficient room for roadway operations.
  - b. maintain safety for traffic, pedestrians and nearby residents.
  - c. direct traffic to alternate routes.
  - d. maintain traffic speed.

## Section One Quiz Answers

1. d. centerline
2. a. station location
3. a. usually set up every 50 feet  
c. the measured distance from the beginning of the roadway project which is used as a reference point for placing stakes established at various breaks in the topography.
4. b. right-of-way  
c. fence line
5. b. horizontal distance to centerline  
c. slope  
d. vertical cut distance
6. a. vertical offset, horizontal offset encircled
7. c. serve as a pay document for the contractor.
8. b. maintain safety for traffic, pedestrians and nearby residents.

## **Section Two: Initial Earthwork Operations**

### **Clearing**

The entire construction area must be cleared to the widths specified in the project plans or as otherwise specified in Special Provisions. Generally, all trees, logs, stumps, roots, brush, grass, trash, and weeds must be removed:

- from areas where structures, frontage roads, streets, ramps, road approaches, ditches, channels, access roads, and connections will be constructed;
- five feet beyond structures, and excavation and embankment slope lines; and
- from areas enclosed by loops or ramps.

### **Grubbing**

As with clearing, the entire construction area must be grubbed according to specifications in the project plans or according to the Special Provisions. The areas which must be grubbed are the same as for clearing.

In non-embankment areas, all stumps, roots, buried logs and other objectionable material must be grubbed to the depth necessary to remove them.

In embankment areas where the subgrade is five or more feet above the natural ground, all trees, stumps, and roots shall be cut off within one foot above the natural ground line. If structures are to be constructed, piles are to be placed, or unsuitable material is to be removed from an embankment area, all trees, stumps and roots must be completely removed. Because grubbing requires excavation, the area should be blue-staked prior to any digging.

Any cavities resulting from grubbing must be backfilled with material approved by the Engineer. This material must be compacted to at least 95 percent of its maximum density.

### **Removal and Disposal of Materials**

All materials removed during clearing and grubbing operations shall be disposed of at approved locations beyond the right-of-way which cannot be seen from the roadway. If the contractor obtains a permit from the Department of Health Services and any other related agency, burning of these materials is allowed. Also, combustible materials may be reduced to chips having a maximum thickness of one-half inch. These chips may be disposed of between the slope lines and right-of-way, or buried or uniformly distributed on the ground and mixed with earth in a non-combustible way. No accumulation of material shall be left on or next to the right-of-way.

## Removal of Structures and Obstructions

There are several general guidelines which must be followed for removal of structures and obstructions. Arrangements for traffic control must be made before any bridges, culverts, or other structures are removed. Any blasting necessary for the removal of existing structures which may damage new construction must be completed before new construction is begun. Any items to be salvaged must be carefully stockpiled or stored. Any holes, cavities, trenches, or depressions resulting from the removal of structures in areas which will not be excavated must be backfilled with suitable material and compacted to 95 percent of its maximum density. Let's look at guidelines for removing specific structures.

When removing **salvable pipe**, it must be cleaned prior to storage or reuse. If existing pipe is to be partially removed, the cut must be smooth, straight and perpendicular to the centerline of the pipe.

**Portland cement concrete pavement** to be removed can be disposed of at approved dumping sites or buried in embankments in accordance with state specifications. If new construction is to join existing concrete pavement, the pavement must be saw cut to a true line with clean, straight vertical edges.

### Removing Existing Bituminous Pavement

Unless milling is specified in the Special Provisions, all bituminous pavement designated on the project plans to be removed, shall be completely removed down to the underlying base course or subgrade. The pavement material shall be removed and disposed of as specified in the Special Provisions.

Any **miscellaneous concrete**, which includes any portions of mortared rubble masonry, curbs, gutters, sidewalks, driveways, aprons, slope paving, island paving, retaining walls, spillways, drainage structures, concrete box culverts, foundations, and footings must be removed at least five feet below the finished subgrade or as otherwise specified in the Special Provisions or Project Plans. If new concrete will be added to existing concrete, care must be taken not to damage existing concrete and the cut must be true with straight vertical edges.

**Bridges** must be removed according to project plans or as specified in the Special Provisions. All salvable materials such as structural steel, structural steel members, timber and other materials must be carefully removed to prevent damage. Piling, piers, abutments, footings, and pedestals must be removed to at least one foot below ground line or five feet below the finished subgrade unless otherwise specified. If partial bridge removal is specified, care must be taken not to damage the remaining portion of the existing structure.

**Signs and delineators must** be removed so not to damage the sign posts. Existing signs should not be removed until new signs have been installed; however, the old signs should not remain over five days.



**Embankment curbs, downdrain inlets, and spillway inlets** to be removed must be carefully taken away to preserve existing bituminous pavement. Use asphaltic concrete to fill and repair voids in the existing pavement surface that result from the removals.

**All fence and guardrail** to be removed shall become the property of the contractor unless it is to be salvaged. Salvable fence and gates must be carefully dismantled and rolled or coiled. Concrete and dirt must be removed from the posts. Care must be taken to prevent the escape of livestock where necessary.

## **Existing Utilities, Property and Landscape**

The contractor must preserve and protect public and private property, land monuments and property markers. If private mail boxes must be moved either permanently or temporarily, mail service must not be interrupted. Existing fences, pole lines, signs, and buildings must also be protected from damage. If the contractor is responsible for any damage to these structures, he is responsible for their repair or restoration to their condition prior to the damage.

The contractor must contact “blue stake” information to determine the location of utilities prior to the new road construction. The contractor must communicate utility location information to the workers directly associated with construction in these areas. The known locations of utilities should be marked. During the construction, the contractor must exercise caution in case the locations of all utilities were not determined before construction began. If utilities that were located prior to construction are damaged during construction operations, the contractor is responsible for their damage.

## Section Two Quiz

1. Which of the following areas should be cleared in preparation for excavation and embankment construction? (Circle one or more)
  - a. areas enclosed by ramps
  - b. areas where ditches will be built
  - c. 5 feet beyond the right-of-way boundaries
  - d. 5 feet beyond embankment slope lines
2. In embankment areas where piles are to be placed, all stumps and buried logs must be grubbed ... (Circle one)
  - a. within one foot of the natural ground line.
  - b. within five feet of the piles to be built.
  - c. so that they are completely removed.
  - d. to the natural ground line.
3. Chipped material **cannot** be disposed of ... (Circle one)
  - a. between the slope lines and rights-of-way.
  - b. by being mixed with earth.
  - c. by being hauled away.
  - d. by being left next to the right-of-way.
4. Which of the following items must be completed prior to the removal of any structures and obstructions? (Circle one or more)
  - a. blasting for removal of existing structures
  - b. stockpile salvable material
  - c. backfill cavities with suitable material
  - d. arrange necessary traffic control
5. Miscellaneous concrete to be disposed of must be removed ... (Circle one or more)
  - a. to the natural ground line.
  - b. at least five feet below the finished grade.
  - c. to the depth specified.
  - d. within one foot of the natural ground line.
6. What material should be used to fill voids left by removed embankment curbs and inlets where asphaltic concrete has been disturbed? (Circle one)
  - a. approved soil
  - b. portland cement concrete
  - c. chipped combustible material
  - d. asphaltic concrete

7. Who is responsible for damaged utilities if their locations were identified prior to construction? (Circle one)
- a. the Department
  - b. the Utility Company
  - c. the Contractor
  - d. the Sub-Contractor

## Section Two Quiz Answers

1.
  - a. areas enclosed by ramps
  - b. areas where ditches will be built
  - d. 5 feet beyond embankment slope lines
2. c. so that they are completely removed.
3. d. by being left next to the right-of-way.
4. d. arrange necessary traffic control
5.
  - b. at least 5 feet below the finished grade, unless otherwise specified.
  - c. to the depth specified.
6. d. asphaltic concrete
7. c. the Contractor

## **Section Three: Excavation Operations**

### **General Requirements**

The contractor must protect highway facilities, utilities, railroad tracks, and other non-highway facilities which will remain in place from damage.

When hauling is done over streets or highways, the loads must be within legal load limits. All materials must be removed from the shelf areas of vehicles to eliminate materials being spilled onto the roadway. Also, the loads must be watered or covered to eliminate dust as necessary.

Suitable excavated material should be used first instead of borrow in the construction of embankments and other areas. Refer to ADOT *Construction Manual* page 203-7 for a Subgrade Acceptance Chart. Material below the line is acceptable.

### **Roadway Excavation**

All roadway excavation shall be finished to a reasonably smooth and uniform surface and shall not vary by more than 0.04 foot above or below the established grade and shall be in reasonably close conformance to the lines, dimensions, and cross sections shown on the project plans or established by the Engineer.

When Portland Cement Concrete Pavement or Asphaltic Concrete Pavement are to be placed directly on the subgrade, the finished surface shall not vary by more than 0.02 foot above or 0.04 foot below the established grade. When roadway excavation is made in rock, the full cross section width of the roadway between the ditches shall be over-excavated a minimum depth of six inches below the subgrade elevation. The over-excavated area shall be filled with embankment material satisfactory to the Engineer and compacted and finished in accordance with the requirements of the Specifications.

In situations where only part of the roadway section intersects areas of rock, that portion occurring in the rock zone shall be over-excavated and backfilled as noted above and brought up to match the adjoining subgrade. The top six inches must be compacted to 95 percent of its maximum density; however, if the asphaltic concrete or Portland Cement Concrete is to be placed directly on the subgrade, the subgrade must be compacted to 100 percent of its maximum density.

**Slopes** must be finished and be free of debris and loose material. All shattered and loosened rock material must be removed. While working on slopes, all landscape features must be protected. The intersection of slopes with natural ground surface should be rounded as shown on the plans or as directed by the Engineer.. Slopes need to be covered or seeded to avoid erosion.

When **blasting** is necessary for roadway excavation, the contractor must submit a blasting plan. No overshooting will be allowed. Also, landscape features must be protected from damage. Pre-splitting blasting procedures are to be used when:

- the slope is 3/4:1 or steeper,
- the cut slope depth is greater than 15 feet, or
- when it is required by the project plans.

When pre-splitting, the drill holes for pre-splitting must be:

- placed no more than three feet apart,
- near to design slope lines, and
- parallel to each other.

All **unsuitable material** below the natural ground surface in embankments and below the subgrade in excavation areas must be removed. The resulting cavities must be filled with suitable material and properly compacted.

**Surplus excavated material** shall not be removed from the job site until approved by the Engineer; however, if a shortage of this material results from its premature disposal, it is the contractor's responsibility to replace it.

## **Grading Roadway for Pavement**

All existing pavement shall be removed as designated on the project plans. Where new asphaltic concrete is to match existing bituminous surfaces, the edges of the existing bituminous surfaces abutting the new paving shall be either saw cut or wheel cut to a minimum depth of 1-½ inches to form a neat, true line with straight vertical edges free from irregularities. Should the contractor elect to wheel cut the edges, the cutter wheel shall be adequate for the work, in the opinion of the Engineer, to produce the desired result.

If at the time of removing any portion of the existing roadway, in-place materials from which the new subgrade is to be constructed contain an excess of moisture, so that the required compaction cannot be obtained with reasonable and customary aeration and manipulation, the Engineer will determine the cause of such condition and will determine whether the material shall be further aerated or removed and replaced.

If the cause of such condition is determined to have been unforeseeable and beyond the control of and without fault or negligence of the contractor, such further work shall be done as directed and will be paid for as extra work in accordance with the requirements of Subsection 104.02. Excess moisture caused by irrigation water, storm drainage, weather, breakage of mains or other similar cause will be considered as within the responsibility of the contractor.

The top six inches of the subgrade shall be compacted to a density not less than 95 percent of the maximum density as determined in accordance with the requirements of Arizona Test Methods 225, 226, and 227, except that when asphaltic concrete or portland cement concrete is to be placed directly on subgrade, the required density shall be 100 percent.

The surface of the subgrade shall be finished to a reasonably smooth and uniform surface and in reasonably close conformity to the lines, grades, dimensions, and cross section shown on the project plans or established by the Engineer. The finished surface of the subgrade shall not vary by more than 0.04 of a foot above or below the grade established by the Engineer except when Portland Cement Concrete Pavement or Asphaltic Concrete are placed directly on the subgrade, it shall not vary by more than 0.02 foot above or 0.04 foot below the established grade.

## **Drainage Excavation**

Drainage excavation includes the construction of ditches, channels, and waterways. It does not include ditches which are parallel to the roadway and part of the roadway prism.

The construction of drainage features must conform to the lines, grades, and slopes as staked. Their construction may extend beyond the right-of-way as necessary to provide outfall; however, permission from the affected property owners must be obtained, which could be a drainage easement.

The surface of the excavated drainage areas should be consistent with the character of the material; absolute smoothness is not required. All waterway features must be excavated to drain effectively. Suitable materials removed from drainage excavations can be used elsewhere in the construction.

## **Structural Excavation and Backfill**

Structural excavation includes the excavation and removal of all materials for the construction of bridges, concrete box culverts, inlet and outlet wings, retaining walls, and other associated items as detailed in the project plans. This excavation must conform to lines, grades, and cross-sections established in the project plans as closely as possible. The sides of excavations must be sloped or shored as required in current OSHA regulations. Do not place backfill material against concrete abutments, concrete retaining walls or cast-in-place concrete structures until the concrete has reached the specified strength or curing time requirement. Approved material must be used for backfill operations. It must be placed in layers and compacted to 95 percent of its maximum density in accordance with project requirements.

## **Grader Ditches**

Grader ditches are triangular-shaped ditches which are generally excavated and finished with a motorgrader (Blade). They must be constructed according to the project plans unless the Engineer makes changes according to the topography, the location of the excavation and their necessary length.

## **Crown Ditches**

Crown ditches are designed to intercept surface water. They must be constructed according to the project plans unless the Engineer makes changes necessary for proper drainage throughout the overall drainage system. The excavated material should be placed on the lower elevation side of the ditch in accordance with the standard drawings.

## **Crown Dike**

The construction of crown dikes involves placing material to the lines and grades necessary to intercept the flow of surface water and to direct it down slopes to a discharge point. They must be constructed according to the project plans or as directed by the Engineer. Suitable material must be used which must be placed in, uniform layers no more than eight inches thick and compacted to at least 95 percent of its maximum density.

## **Borrow**

Borrow shall be secured from material sources in accordance with the requirements of Section 1001. The material shall be of a quality suitable for the purpose intended, free of vegetation or other unsatisfactory material. Borrow placed within three feet of finished subgrade elevation shall have a soil support value equal to or greater than the design soil support value for the pavement structure of the area in which the borrow will be placed. This will be given as an equation in Subsection 203-9.02 of the Project Special Provisions. The equation will look like:

$PC + (2.83 \times PI)$  shall not exceed XX.

(PC = % of material passing the No. 200 sieve and PI = Plasticity Index.)

Measurement of borrow for payment will be similar to Roadway and Drainage Excavation in accordance with Subsection 203-2.01. When adjustments are required, Borrow will be documented for payment as shown in the bidding schedule by either of the two following methods:

When the contract provides for Borrow (Pit), the borrow will be measured by the cubic yard in the original space occupied and volume of material removed will be computed in cubic yards by the average end area method.



When the contract provides for Borrow (Pit), the borrow will be measured by the cubic yard in the original space occupied and volume of material removed will be computed in cubic yards by the average end area method.

No measurement for payment will be made for borrow material placed prior to completion of roadway excavation, drainage excavation or structural excavation, when such placement results in unauthorized wasting of roadway, drainage or structural excavation materials.

## **Furnish Water Supply**

The work under this section shall consist of either developing or obtaining water supply and furnishing all water required for the work.

Material may be watered either at the source or on the roadway, at the option of the contractor.

If the contractor elects to apply water to materials at the source, and these materials will subsequently be measured and paid for on the basis of weight, the contractor shall give the Engineer ample notice of its intentions. Prior to the application of water, the contractor shall furnish such equipment and labor as may be necessary to enable the Engineer to obtain samples for determining the in-place moisture materials. The difference in weight between the average in-place moisture content of the material prior to pre-wetting and the average moisture content of the material at the time of weighing will be deducted from the total weight of the material.

## **Furnish Water**

The work under this section shall include furnishing all water, for the control of dust as considered necessary for public safety and convenience of the traveling public, for the reduction of the dust nuisance to adjacent property, for allaying of dust in non-commercial crusher and pit operations and on roads used to haul material, and for other purpose as directed by the Engineer.

Water applied for dust control shall be as approved or directed by the Engineer. The contractor shall provide appropriate equipment for effective control of dust.

The cost for application and distribution of water required for construction shall be considered as included in other related contract items, such as earthwork, subgrades, base courses, and backfill materials as appropriate.

The cost for distributing and applying water for dust control, including the water truck and all fittings and equipment and labor involved will be considered as included in other contract items.

When volumes computations are necessary it is helpful to review “Geometric Solutions” in Chapter 13 of the *Construction Manual*.

## Section Three Quiz

1. Which of the following is not a pre-existing condition for pre-splitting blasting procedures? (Circle one)
  - a. significant rock material must be removed
  - b. when it is required by the project plans
  - c. the slope is 3/4:1 or steeper
  - d. the cut slope depth is greater than 15 feet
2. If asphaltic concrete is to be placed directly onto the subgrade, the subgrade must be compacted to ... (Circle one)
  - a. 95 percent of its maximum density.
  - b. 100 percent of its maximum density.
3. Drainage excavation does not include ... (Circle one)
  - a. ditches perpendicular to the roadway.
  - b. ditches parallel to the roadway and part of the roadway prism.
  - c. ditches beyond the roadway.
4. Structural excavations must conform to these items in the project plans: (Circle one or more)
  - a. lines
  - b. grades
  - c. cross-sections
  - d. moisture standards
5. Crown ditches are designed to ... (Circle one)
  - a. direct water to catch basins.
  - b. intercept surface water.
  - c. direct water to slopes.

## Section Three Quiz Answers

1. a. significant rock material must be removed
2. b. 100 percent of its maximum density.
3. b. ditches parallel to the roadway and part of the roadway prism.
4. a. lines  
b. grades  
c. cross-sections
5. b. intercept surface water.

## **Section Four: Embankment Construction**

### **Embankment Materials Requirements**

Embankment construction includes the construction of roadway embankments, dikes and berms, as well as the placement and compaction of material wherever unsuitable material has been removed. This construction also includes the placement and compaction of materials in holes, pits and other depressions.

Suitable excavated material from within the right-of-way or borrow from beyond the right-of-way can be used for embankment construction. This material must be free of vegetation and other unwanted debris. If the borrow is to be placed within three feet of the finished subgrade, it must have a soil support value equal to or greater than the design soil support value of the pavement structure in the area where the borrow will be placed. The soil support values are related to the R-value, Resilient modulus value, or subgrade acceptance chart for the soil to be incorporated into the embankment. Materials to be placed next to newly constructed metal bridge piles must meet specified resistivity and pH values.

### **Placement of Embankment Materials**

Prior to embankment construction, clearing and grubbing for the area must be completed. If the embankment material is to be placed over an existing bituminous surface, this surface must be scarified before construction gets under way.

All embankments shall be constructed to a reasonably smooth and uniform surface and shall not vary by more than 0.04 foot above or below the grade established and in reasonably close conformity to the lines, dimensions, and cross sections shown on the project plans or established by the Engineer. When Portland Cement Concrete Pavement or Asphaltic Concrete are to be placed directly on the subgrade, the finished surface shall not vary by more than 0.02 foot above or 0.04 foot below the established grade.

Embankment construction shall not be started until clearing and grubbing for the embankment area is completed. When embankment material is to be placed over existing bituminous surfacing, the surfacing shall be scarified prior to placing embankment material, unless otherwise directed by the Engineer.

When the embankment material, resulting from the required excavations, consists predominately of rock fragments of such size that the material cannot be placed in an eight-inch layer without crushing, pulverizing or further breaking down the pieces, such material may be placed in the embankment in layers not exceeding thickness the approximate average size of the larger rocks being excavated, but not larger than 2 feet. It may be necessary to reduce the size of the excavated material by crushing or otherwise breaking down the material in order to comply with this requirement.

The placing of individual rocks and boulders greater than 24 inches in diameter will be permitted provided they do not exceed 36 inches in maximum dimensions, are carefully distributed to prevent nesting, and the interstices are filled with finer material and compacted to form a dense and compact mass. Each layer shall be leveled and smoothed by evenly distributing spalls and finer fragments of rock and earthen material with suitable leveling equipment.

Embankment material containing broken concrete, rock or other solid materials which are larger than six inches in greatest dimension shall be placed so that no surface of said material is within three feet horizontally of any piling, structures pole or sign foundations and underground conduit. It may be necessary to reduce the size of the excavated material by crushing or otherwise breaking down the material in order to comply with this requirement.

## **Geotextile Fabric**

The separation geotextile fabric shall be supplied in accordance with and conform to the material requirements of Sections 1014-1 and 1014-4. Special attention shall be given to the required survivability of the fabric material which will be as called out in the Special Provisions or as shown on the plans.

### **Fabric Packaging, Handling, and Storage**

The identification, packaging, handling and storage of the geotextile fabric shall be in accordance with ASTM D 4873. Fabric rolls shall be furnished with suitable wrapping for protection against moisture and extended ultraviolet exposure prior to placement. Each roll shall be labeled or tagged to provide product identification sufficient to determine the product type, manufacturer, quantity, lot number, roll number, date of manufacture, shipping date, and the project number and name to which it is assigned. Rolls will be stored on the site or in another identified storage location in a manner which protects them from the elements. If stored outdoors, they shall be elevated and protected with a waterproof, light colored, opaque cover. At no time shall the fabric be exposed to sunlight for a period exceeding 14 days.

### **Weather Limitations**

Separation geotextile fabric shall not be placed when weather conditions, in the opinion of the Engineer, are not suitable to allow placement or installation. This will normally be at times of wet or snowy conditions, heavy rainfall, extreme cold or frost conditions or extreme heat.

## **Equipment**

Mechanical or manual laydown equipment shall be capable of handling full rolls of fabric, and laying in the fabric smoothly, without wrinkles or folds. The equipment shall be in accordance with the fabric manufacturer's recommendations or as approved by the Engineer.

## **Surface Preparation**

The surface upon which the separation fabric will be placed shall be compacted and finished according to the requirements of the *Standard Specifications*.

## **Fabric Placement**

The separation geotextile fabric shall be unrolled on the finished surface and laid smooth without wrinkles. The placement of fabric by dragging across the finished surface will not be allowed. The geotextile fabric shall be overlapped a minimum 24 inches for longitudinal and transverse joints. The center of a longitudinal overlapped joint shall be located in the same manner as a longitudinal pavement joint according to Subsection 406-6. Transverse overlaps shall be in the direction of aggregate placement.

## **Placement and Compaction of Aggregate**

Aggregate materials shall be placed by back-dumping the aggregate in a manner which does not damage the fabric and then spreading the aggregate material onto the geotextile fabric in a constant forward direction. Traffic or construction equipment shall not be permitted directly on the geotextile unless approved by the Engineer for emergency purposes. Pins or piles of aggregate can be used to hold the geotextile in place while it is being covered.

Overstressing the subgrade soil shall be avoided by utilizing equipment in spreading and dumping that exerts only moderate pressures on the soil. If ruts of 2 inches or greater occur in the aggregate, the contractor shall use lighter equipment which transmits less ground pressure. Any ruts which develop during spreading or compacting aggregate shall be filled with additional aggregate rather than bladed from adjacent areas so that the final design aggregate thickness is maintained. Construction equipment shall not be allowed to turn or stop suddenly on the aggregate placed over the geotextile fabric.

Aggregate base shall be compacted as specified in Subsection 303-3.02. Aggregate base material shall not be mixed or processed on the separation geotextile fabric. The aggregate base material shall be premixed at the stockpile area or at another location in a manner approved by the Engineer. Aggregate base materials will be sampled for acceptance after premixing and prior to placement on the separation fabric. Contamination and segregation of aggregate base materials prior to or during placement shall be minimized.

Any damage to the fabric occurring during placement of the aggregate must be repaired immediately. The aggregate shall be removed from the damaged area to allow placement of a

fabric patch extending 3 feet on all sides beyond the damaged area, followed by replacement of the aggregate.

## **Embankment Compaction**

Each uniform layer must be compacted to the specified density before the next layer is added. As necessary to obtain the required density, the contractor will often need to add water so that the material is at or near its optimum moisture content.

If the embankment to be constructed is five feet or less, then the top six inches of the existing material on which the embankment will be placed must be compacted to 95 percent of its maximum density.

Each layer of a roadway embankment must be compacted to 95 percent of its maximum density; however, if asphaltic concrete is to be placed directly on the subgrade, the top six inches of the embankment must be compacted to 100 percent of its maximum density. Material to be placed in dikes must be compacted to at least 95 percent of its maximum density.

If the embankment is primarily made of rock and the rocky materials are such that they cannot be tested by approved methods, the density requirements will not apply. Rocky material must be placed, spread, and leveled in maximum 24 inch layers, when possible, with sufficient fines included in the material to fill the voids between the rock particles. The average dimension of the largest rock shall not exceed 24 inches. Vibratory compactors, grid rollers or other heavy compaction equipment shall be used to compact rocky embankment materials. Further compaction shall be accomplished by routing the hauling equipment uniformly over the entire width of the embankment. Rolling may be omitted by the Engineer in only very special cases when it is deemed impractical.

Because compaction compliance is determined by visual observations of the inspectors, normal density testing should be performed in areas of granular soils where it is possible to establish the number of roller passes necessary to achieve the 95% density requirement. Using the same number of roller passes on rocky materials, it would be reasonable to expect that density could be achieved in a similar manner.



## Section Four Quiz

1. Material within the right-of-way which is suitable for embankment construction must be free of ... (Circle one or more)
  - a. rocks.
  - b. vegetation.
  - c. unwanted debris.
2. When embankment material is to be placed over an existing bituminous surface, this surface must be ... (Circle one)
  - a. recycled.
  - b. removed.
  - c. scarified.
  - d. replaced.
3. New layers in embankment should be ... (Circle one or more)
  - a. parallel to the slope.
  - b. of uniform thickness.
  - c. no more than 8 inches thick.

## **Section Four Quiz Answers**

1. b. vegetation.  
c. unwanted debris.
2. c. scarified.
3. b. of uniform thickness.  
c. no more than 8 inches thick.

## Section Five: Documentation

This section summarizes the documentation involved in inspecting excavations and embankments in terms of:

- measurements as the basis for payment,
- key information and events to be documented, and
- the records and reports used.

### Measurements for Payments

The basis of payment for excavation and embankment operations is usually on a line-item basis or a combination of line items and lump-sum items. Let's look at some typical line items as they apply to these operations.

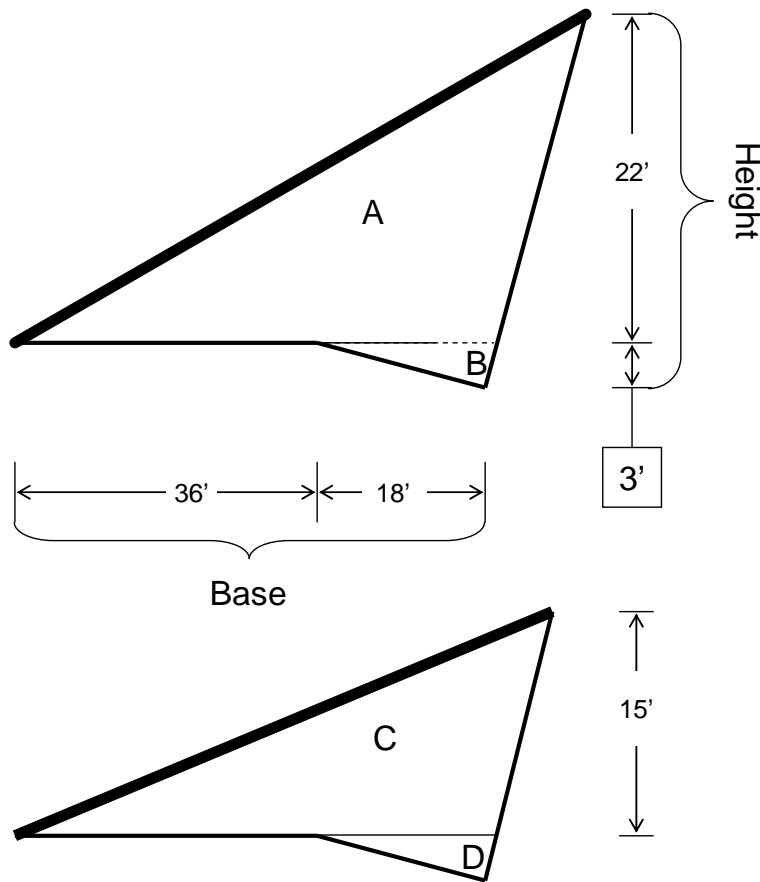
#### Line-Item Payments

Although the Special Provisions section identifies specific items, typical line items might include:

- **clearing and grubbing** – measured either:
  - as a lump sum, or
  - to the nearest tenth of an acre;
- **removal of obstructions and structures** – measured either:
  - as a lump sum, or
  - by item as specified in the contract;
- **roadway excavation** – measured by cubic yards using the average end area method or predetermined bid quantity;
- **grading roadway for pavement** – measured by the square yard of the area prepared and subsequently covered with a subbase, base, asphaltic concrete or portland cement concrete; however, when raised median islands are constructed, the area occupied by these islands will be included in the area measured for payment;
- **drainage excavation** – measured by cubic yards using the average end area method or predetermined bid quantity;
- **structural excavation and backfill** – measured in cubic yards as calculated in the pay limits found in the project plans or as a predetermined bid quantity in the lump sum structure pay item;
- **borrow** – measured by cubic yards using the average end area method or predetermined bid quantity;
- **embankment** – no payment is made for hauling, placing, shaping, applying water or compacting embankment material; and

## Volume Calculations by the Average End Area Method

Volumes of materials are frequently paid by the cubic yard. The following example shows a typical excavation calculation; the same principles apply to drainage excavation, structural excavation, backfill, borrow, embankment or any other item that is paid for by the cubic yard.



Scale: 1"=12',  
1/6" = 2'

## Volume Calculations by the Average End Area Method

Step 1: Calculate the area for each of the triangles (there are four)

Step 1a: The area of a triangle is calculated using the equation  $\frac{1}{2} \times \text{Base} \times \text{Height}$

Step 1b: Area calculation for triangle A:

$$\text{Height} = 22 \text{ feet, Base} = (36 \text{ feet} + 18 \text{ feet}) = 54 \text{ feet}$$

$$\text{Area of triangle A} = \frac{1}{2} \text{ Base} \times \text{Height} \gg 0.5 \times 54\text{ft} \times 22\text{ft} = 594 \text{ square feet or sq. ft.}$$

Step 1c: Area calculation for triangle B:

$$\text{Height} = 3 \text{ feet, Base} = 18 \text{ feet}$$

$$\text{Area of triangle B} = \frac{1}{2} \text{ Base} \times \text{Height} \gg 0.5 \times 18 \times 3 = 27 \text{ square feet or sq. ft.}$$

Step 1d: Area calculation for triangle C:

$$\text{Height} = 15 \text{ feet, Base} = (36 \text{ feet} + 18 \text{ feet}) = 54 \text{ feet}$$

$$\text{Area of triangle C} = \frac{1}{2} \text{ Base} \times \text{Height} \gg 0.5 \times 54 \times 15 = 405 \text{ square feet or sq. ft.}$$

Step 1e: Area calculation for triangle D:

It can be assumed that triangle B and D are the same since no more information is given for triangle D, therefore the area of triangle D = 27 square feet or sq. ft.

Step 2a: Add the areas of triangles A and B (End Area 1)

$$\text{Area of triangle A} = 594 \text{ sq. ft., Area of triangle B} = 27 \text{ sq. ft.}$$

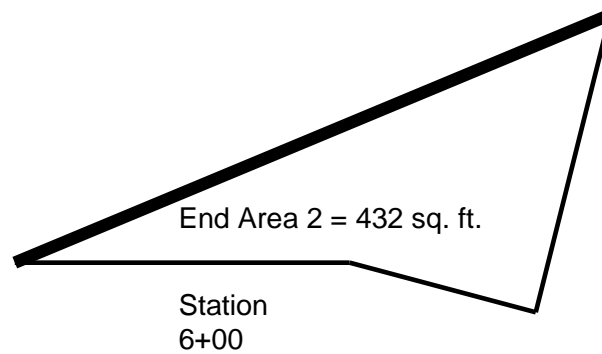
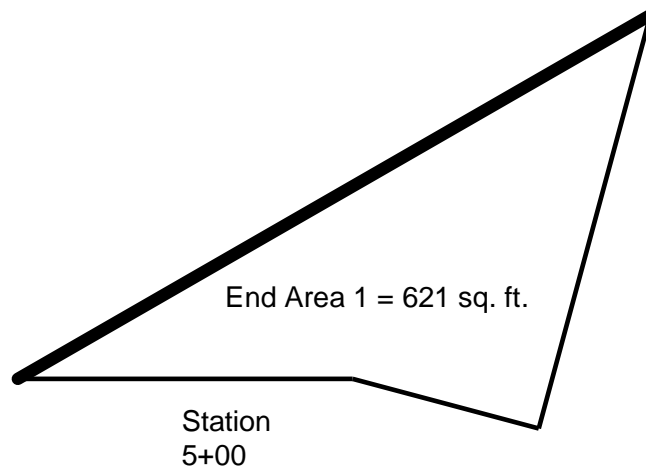
$$\text{End Area 1} = 594 \text{ sq. ft.} + 27 \text{ sq. ft.} = 621 \text{ sq. ft.}$$

Step 2b: Add the areas of triangles C and D (End Area 2)

$$\text{Area of triangle C} = 405 \text{ sq. ft., Area of triangle D} = 27 \text{ sq. ft.}$$

$$\text{End Area 2} = 405 \text{ sq. ft.} + 27 \text{ sq. ft.} = 432 \text{ sq. ft.}$$

## Volume Calculations by the Average End Area Method



## **Volume Calculations by the Average End Area Method**

Step 3: Calculate Average End Area

Step 3a: Add End Area 1 and End Area 2

$$\text{End Area 1} = 621 \text{ sq. ft.}, \text{ End Area 2} = 432 \text{ sq. ft.}$$

$$\text{End Area 1} + \text{End Area 2} = 621 \text{ sq. ft.} + 432 \text{ sq. ft.} = 1053 \text{ sq. ft.}$$

Step 3b: Find the Average End Area

$$\text{Average End Area} = \text{Total End Area} / \text{Total number of End Areas}$$

$$\text{Average End Area} = 1053 \text{ sq. ft.} / 2 \text{ End Areas (End Area 1 and End Area 2)}$$

$$\text{Average End Area} = 526.5 \text{ sq. ft.}$$

Step 4: Calculate volume given the Average End Area

$$\text{Volume} = \text{Average End Area} \times \text{Length (sq. ft.} \times \text{ft.} = \text{cu. ft.)}$$

$$\text{Volume} = 526.5 \text{ sq. ft.} \times 100 \text{ ft. (station 5+00 to 6+00)}$$

$$\text{Volume} = 52650 \text{ cubic feet or cu. ft.}$$

Convert feet to yards by dividing by 27 (cubic feet/cubic yard) for payment purposes.

$$\text{Volume in cubic yards} = 52650 \text{ cu. ft.} / 27 = 1950 \text{ cu. yd.}$$

## Key Information and Events

Some of the key information and events that need to be documented for excavation and embankment operations is similar to that of any construction work including:

- **routine information** – such as the type of work being done, the project, the location, the time of the work and the weather; and
- **special events or problems** – including any unusual conditions, instructions to the contractor, rejected work or materials and corrective actions taken by the contractor.

Other key items of information and events that need to be documented specifically for excavation and embankment operations include:

- blasting:
  - overshooting, or
  - overbreakage;
- confirmation of cross-sectioning;
- number of lifts:
  - borrow,
  - excavated material to be reused in construction, and
  - excavated material to be discarded;
- results of moisture and density testing;
- which personnel worked on these operations and for what length of time:
  - clearing,
  - compacting,
  - drainage,
  - embankments,
  - excavation,
  - grubbing; and
- which types of equipment were used for these operations and for what length of time:
  - clearing,
  - compacting,
  - drainage,
  - embankments,
  - excavation, and
  - grubbing.



## **Records and Reports**

The principal records and reports used in documenting excavation and embankment operations are the:

- Daily Diary,
- Quantity Reports, and
- Sampling and Testing Documents.

### **Daily Diary**

The Daily Diary serves as both a record and a report of all key events that occur during the day. All Daily Diaries are the property of the Department and serve as the foundation of all construction project records, so they must be maintained neatly and legibly in ink. They are generally a summary of key events and information, but they must provide sufficient detail so that other personnel can get an accurate picture of what happened each day.

The items recorded in the Daily Diary include:

- such routine information as:
  - identification of the project,
  - the type of work being done,
  - the location of the work,
  - the times work is started and stopped,
  - weather conditions,
  - any important phone calls or other communications sent or received, and
  - an inventory of the contractor's equipment and personnel resources being used on the work;
- information on any special events or problems encountered such as:
  - any official visits to the project,
  - unusual conditions that may affect the work,
  - the times and causes of delays,
  - important discussions with the contractor and any specific instructions or orders given,
  - the rejection of any materials or work including the reasons for the rejection,
  - any changes, adjustments or corrective actions by the contractor, and
  - any other information that may be relevant to any potential disputes or claim; and
- summaries of the excavation and embankment work under way or completed during the day including the type and location of any:
  - backfilling,
  - clearing,
  - compacting,
  - drainage,
  - embankments,
  - excavation, and
  - grubbing.

## **Quantity Reports**

The Quantity Report is used to record detailed technical information on the work and the bid item quantities. Because it is also a key part of the Department's permanent record of the work, all entries must be made neatly, clearly and accurately.

It can take the place of that day's daily dairy because it has a place to record the events besides a computation pad. On many projects, the Pen-base hand-held computer is taking the place of the paper forms.

For excavation and embankment operations, the technical information recorded in the Quantity Report should include calculations and diagrams used in such inspection activities as when there is no predetermined or lump sum quantities:

- checking layout and grade controls;
- determining structural excavation quantities;
- checking compressive strength of poured concrete;
- calculating backfill quantities; and
- measuring structural pay quantities.

In excavation and embankment work, the Quantity Report or Daily Dairy should also include:

- the number of lifts for a given task;
- identification of the quantities for dust palliatives;
- the number of acres cleared and grubbed;
- results of moisture and density tests; and
- dates for completion of each task.

## **Sampling and Testing**

The inspector must sample and test all materials used in excavation and embankment operations through these documents and record the results of testing performed on samples sent to the lab for proctor, gradation, and plasticity index tests.